



## Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

**THE COMPOSITION AND ECOLOGICAL RELATIONS OF THE ODONATE FAUNA  
OF MEXICO AND CENTRAL AMERICA.**

BY PHILIP P. CALVERT.

## CONTENTS.

- General Conditions determining Odonate Distribution.  
The Chief Odonatological Features of Mexico and Central America.  
Relations of the Mexican-Central American Odonate Fauna to those of other Areas.  
Distribution of the Odonata within limited portions of Mexico and Central America.  
Relations of the Odonate Fauna of Mexico and Central America to Temperature, Rainfall, Vegetation Areas and Altitude.

The preparation of an extended account<sup>1</sup> of the Odonata of Mexico and Central America has induced me to study the relations of these insects to various factors of their environment, with the results here set forth. The facts on which this study is based, in so far as the Odonata are concerned, are contained in the *Biologia* volume, to which reference must be made for further details. Since the completion of that work, I have received, through the kindness of Mr. H. T. Van Ostrand, specimens of *Enallagma prævarum*, *Oplonæschna armata* and *Sympetrum illotum virgulum*, taken at or near Real del Monte, Hidalgo, Mexico, which add to our knowledge of the distribution of these three species as given in the *Biologia*. The first and third are labelled as having been captured at 9,000 feet elevation, or the highest altitude yet recorded for Odonata in Mexico or Central America. These additional data are included in the following pages.

## GENERAL CONDITIONS DETERMINING ODONATE DISTRIBUTION.

The actual distribution of the Odonata is determined by the conditions under which their aquatic larvæ are able to exist. The distribution of the larvæ, so far as the present region is concerned, is almost entirely unknown. Our present information refers to the appearance of the imagoes in certain localities, and the summary herewith presented

---

<sup>1</sup> Odonata, by P. P. Calvert, forming pp. 17-420 and Introduction, pp. v-xxx of volume *Neuroptera* of the *Biologia Centrali Americana*, edited by F. D. Godman. London, 1901-1908. 4to. 9 plates, 1 map.

rests on the unproven assumption that the adults do not wander far from the waters in which they have passed their earlier stages or in which their offspring are capable of surviving. This assumption is one of the weaknesses in the following attempted generalizations; another is the real scantiness of our knowledge of the distribution of even the winged individuals. How scanty this is may be seen by a glance over the list of localities in Honduras, Nicaragua, etc., in Table A and in the columns for these countries in Table B of the Introduction to the *Biologia* volume quoted and a study of Tables 6-8 of the present paper.

It must be distinctly understood, therefore, that all which follows is subject to future correction in these two important particulars. In spite of these disadvantages, however, some generalization has been deliberately attempted, in the belief that by so doing progress in investigation will be hastened much more than if no such summary were ventured.

#### THE CHIEF ODONATOLOGICAL FEATURES OF MEXICO AND CENTRAL AMERICA.

These are: the practical absence of the subfamily Cordulinæ,<sup>2</sup> some species of which have been recorded from corresponding latitudes in the Old World.

Absence of the following genera, conspicuous or well developed in other parts of America: (a) in Northern America,<sup>3</sup> *Ophiogomphus*, *Gomphus*, *Dromogomphus*, *Octogomphus*, *Celithemis*, *Leucorhinia*; (b) in South America, *Lais*, *Thore*, *Euthore*, *Microstigma*, *Telagrion*, *Leptagrion*, *Diastatops*, *Potamothemis*; (c) in the West Indies, *Scapanea*.

The small number of genera, seven out of seventy-one, which are restricted to this area. They are *Pseudostigma*, *Thaumatoneura*, *Paraphlebia*, *Hesperagrion*, *Anisagrion*, *Oplonæschna* and *Pseudoleon*. Three of these (*Hesperagrion*, *Oplonæschna*, *Pseudoleon*) embrace only one species each. *Oplonæschna* and *Pseudoleon* should be good fliers and, therefore, one would not expect their limited distribution.

The unity of the district, in that only one genus (*Hesperagrion*) is restricted to Mexico north of the Isthmus of Tehuantepec, none to the

<sup>2</sup> Already pointed out by Carpenter, *Scient. Proc. Roy. Dublin Soc.* (n. s.), VIII, p. 450 (1897).

<sup>3</sup> Throughout this memoir, as in the *Biologia* volume on Odonata, by "Northern America" is meant all north of central California, Arizona, New Mexico, Texas and (east of this last) of the 30th parallel of north latitude.

area between the latter and the Isthmus of Nicargúa and only one (*Thaumatoneura*) to the Costa Rican-Panaman section.

The predominant Calopterygine genus is *Hetærina* with 17 species out of 23 for the subfamily. Several species (*H. americana*, *tricolor*, *titia*, *macropus*, *capitalis*) show a marked tendency to reduction in size of the pterostigma in some of the western portions of their ranges, but the geographical areas in which this reduction is strongly marked for one species (e.g., *macropus* in Guatemala) are not necessarily those in which it is displayed by another (e.g., *americana*). *Amphipteryx* is interesting as presenting some features intermediate between those of this subfamily and the *Agrioninæ*. Only one Old World genus (*Calopteryx*) is represented and its existence here rests on a single specimen.

*Lestinæ*. Six of the 7 species belong to the cosmopolitan *Lestes*.

*Agrioninæ*. Of 24 genera, 3 only (*Argia*, *Enallagma*, *Ischnura*) have been recorded from the Old World. Five of the 7 endemic Odonate genera belong here. Of the 112 species, 48 belong to *Argia*; next follow *Protoneura* with 7 species and *Telebasis* with 6. Six species (of 3 genera) are of the exclusively Neotropical Pseudostigmatina, including some of the linearly largest known Odonata of the world.

*Gomphinæ*. None of the genera are extra-American. *Erpetogomphus* is the predominant genus of the subfamily in the northern part of our district, *Epigomphus* in the southern.

*Cordulegasterinæ*. The single genus of our area, *Cordulegaster*, is Holarctic.

*Æshninae*. Three (*Anax*, *Æshna*, *Gynacantha*) of the six genera are also found in the Old World, but none of the species extends thither. One of the seven endemic genera belongs here (*Oplonæschna*). *Æshna* has the largest number of species.

*Cordulinæ*. The single record for this subfamily, from near the northern limit of our district, is of the Holarctic and Palæotropical *Macromia*.

*Libellulinæ*. Of 28 genera, one (*Pseudoleon*) is endemic, five (*Libellula*, *Tholymis*, *Tramea*, *Pantala*, *Sympetrum*) are regarded as also occurring in the Old World. The only Odonate species common to our area and to the Old World—*Pantala flavescens* (and *Sympetrum corruptum*?)—are of this subfamily. Predominant genera are *Libellula*, *Micrathyria*, *Orthemis*, *Erythrodiplax*, *Brechmorhoga*, *Tramea*, *Perithemis* and *Erythemis*.

RELATIONS OF THE MEXICAN-CENTRAL AMERICAN ODONATE FAUNA  
TO THOSE OF OTHER AREAS.

The study of the species of Odonata found over large parts of Mexico has shown that, to the northward, many of them occupy also considerable portions of Texas, New Mexico, Arizona, and California (in the last named possibly to San Francisco), although their northern boundary line has not been determined in any of these States.<sup>4</sup> Therefore, all species, subspecies or varieties found in Mexico and Central America and which may extend also into these four States of the United States, but not beyond them, nor into the West Indies nor South America, have been considered as *endemic*. With this explanation, which applies to all the tables in this paper, the general relations of the Odonate fauna may be learned from an inspection of Table 1.

A further analysis of the relations of the fauna is given in Table 2, wherein, passing from north to south and, in Mexico, from plateau to lowlands, the decrease in the northern element and the increase in the southern element is clearly shown. Even on the Mexican plateau, excluding its highest portion,<sup>5</sup> as the most northern and most elevated section of the present faunal district, the southern element, measured by the number of the "exclusively South American" species, is almost as strong as the northern, represented by the "exclusively Northern American" species<sup>6</sup>—a striking fact when the narrow land connection with South America is contrasted with the very much wider union with the United States, and the geological history of the plateau is borne in mind. It is of further interest to note that while 15 exclusively Northern American species are found on the plateau, 14 Northern American species are found in Mexico exclusive of the plateau, the corresponding figures for the exclusively South American species being 14 and 50. These differences are in agreement with Gadow's

<sup>4</sup> The existing data for about 40 Mexican species would seem to show that their northern boundary line *may* correspond with the upper limit of the *Upper Sonoran* of Merriam (Map in Bull. 10, U. S. Dept. Agric., Div. Biol. Surv., 1898) in California, Arizona and New Mexico; but not east of the last named, as in Texas these species are not yet known as far north as the upper limit of Merriam's *Lower Sonoran*.

<sup>5</sup> The Distrito Federal embraces much of the highest portion of the Mexican plateau, having an elevation of 7200–8000 ft. or 2200–2450 m., and has been fairly well examined as regards its Odonate fauna, which numbers 21 species, etc. Outside of Mexico and Central America, 6 of the 21 occur exclusively in Northern America and 2 of the 21 exclusively in South America, so that here the southern element is weak.

<sup>6</sup> Contrast on this feature Bates, *Biol. Centr. Amer. Coleop.*, I, pt. 1, p. vi, and W. Horn, *Deut. ent. Zeitschr.*, 1897, pp. 161–2.

TABLE 1.—DISTRIBUTION BY SUBFAMILIES OF THE ODONATA OF MEXICO AND CENTRAL AMERICA.  
 ("Spp." includes species, subspecies and varieties.)

Subfamilies.	Distribution in America elsewhere than Mexico and Cent. Amer.																	
	Totals.			Endemic.			Exclusive- ly North- ern Am.			Exclusive- ly North- ern and W. Ind.			Northern, S. Amer. and West Indies.			Exclusive- ly West Indies.		
	gen.	spp.	gen.	spp.	gen.	spp.	gen.	spp.	gen.	gen.	spp.	gen.	spp.	gen.	spp.	gen.	spp.	gen.
Calopteryginae.....	4	23	0	11	1	2	0	0	0	1	1	0	0	1	0	1	2	7
Lestinae.....	2	7	0	3	0	0	0	0	1	1	1	0	0	0	0	2	0	1
Agrioninae.....	24	112	5	80	0	4	0	0	0	2	4	2	2	4	5	2	8	18
Gomphinae.....	5	28?	0	25	1?	2	0	0	0	0	1	0	0	0	1	0	2	1
Cordulegasterinae.....	1	2	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Aeshninae.....	6	23	1	3	1	3	0	1	0	0	2	1	0	1	1	6	1	8
Cordulinae.....	1	1	0	1?	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Libellulinae.....	28	97	1	16	2	10	0	3	1	1	6	4	0	6	13	22	5	35
Totals.....	71	293	7	141?	7	21	0	4	2	5	15?	7	2	12	20	33	18	70
Equivalent percentages of the Totals.....	100	100	9.8	48.1?	9.8	7.2	0	1.4	2.8	1.7	21.1	2.4	2.8	4.0	28.2	11.3	25.4	23.9

<sup>7</sup>The endemic species of birds of this region are equivalent to 45% of the whole number (Godman, *Biol. Cent.-Amer., Aves*, I, p. vi). This percentage is of some interest in comparison with that of actively flying insects like the Odonata.

TABLE 2.—DISTRIBUTION OF THE ODONATA OF CERTAIN PARTS OF MEXICO AND CENTRAL AMERICA.  
 ("Spp." = as in Table 1.)

Area.	Totals.	Distribution in America elsewhere than Mexico and Cent. Amer.														
		Exclusive- ly other parts of the Mex.- C. Amer. district.			Endemic in the area named.			Exclusive- ly North- ern Am.			Exclusive- ly North- ern and W. Ind.			Northern, S. Amer. and West Indies.		
		gen.	spp.	gen.	spp.	gen.	spp.	gen.	spp.	gen.	spp.	gen.	spp.	gen.	spp.	
Mexican plateau (as shown on map).....	35	81	0	1	25	4	15	0	3	2	3	15	4	0	3	
Mexico exclusive of plateau.....	61	212 (215)	1	51	5	44	5	14	0	4	2	5	15	6	1	
Mexico (as in Table 5).....	62	219 (221)	1	51?	5	45	6	19 (20)	0	4	2	5	15	6	1	
Guatemala.....	62	161 (63)	0	14	5	48 (50)	3?	5?	0	0 (2)	2	4 (5)	15 (15)	5 (6)	2	
Costa Rica.....	41 (61)	101 (165)	0	15	3	33) (33)	2	1	0	2 (2)	2	3 (3)	11 (5)	1 (1)	0	

The parentheses ( ) in this and the following tables enclose the probable numbers of genera and species, etc., in the areas in question, obtained by adding to those actually found there those which have been taken both north and south.

results for Reptiles and Batrachia: "The plateau seems to be a much more effective barrier to the southerners than is the descent into the hot lowlands to the northern creatures."<sup>8</sup>

The West Indies lie within the same parallels of latitude as do Mexico and Central America. The total number of species of Odonata found in those islands is about 91;<sup>9</sup> 56 of these, or 61.5%, also occur in our present district. The number of species common to both is likely to be increased by future explorations, especially as the Odonate fauna of Yucatan and British Honduras, the continental areas lying nearest to the West Indies, is very imperfectly known. But, making use of the present figures, it is rather surprising that only 61.5% of the West Indian Odonata are found in Mexico and Central America, seeing that the prevalent winds on the east coast of the mainland are easterly (*i.e.*, northeast, east and southeast).<sup>10</sup> With such insects as the Odonata one might expect the winds to play an important part as means of dispersal.<sup>11</sup> The West Indian species not yet found in Mexico or Central America include a number of fair-sized and probably fair-flying species, *e.g.*, *Aphylla producta*, *Progomphus integer* and *serenus*, *Dythemis rufinervis*, *Scapanea frontalis*, *Macrothemis celæno*, *Celithemis eponina*, etc.

The extent to which species common to the West Indies are found in some parts of Mexico and Central America is shown in Table 3.

The *Endemic Genera and Species* are summarized in Table 4, p. 468.

Of the genera listed in Table 4 as occurring in both Northern and South America, *Heterina*, *Argia*, *Progomphus*, *Erythrodiplax*, and perhaps *Dythemis*, are represented by a greater number of species in South America than in Northern America, and these genera are entirely,

<sup>8</sup> *Proc. Zool. Soc. London*, 1905, II, p. 239.

<sup>9</sup> Hagen, *Proc. Bost. Soc. Nat. Hist.*, XI, pp. 289-294 (1867); XVIII, pp. 20-96 (1875). Uhler, *l.c.*, XI, pp. 295-298 (1867). Kolbe, *Archiv f. Naturges.*, LIV, I, pp. 153-178 (1888). Kirby, *Ann. and Mag. Nat. Hist.*, (6) XIV, pp. 261-269 (1894). Carpenter, *Journ. Inst. Jamaica*, II, pp. 259-263 (1896). Calvert, *Biol. Cent. Amer. Neurop. Introd.*, Table B (1908).

<sup>10</sup> See the charts of prevailing winds accompanying Buchan's *Challenger Report on Atmospheric Circulation*, and the data given in Table VII of the Appendix thereto, pp. 169, 170, for Matamoras and Cordova, Mex., and Belize; also the data for Merida, Campeche and Jalapa by Moreno y Anda and Gomez in *El Clima de la Republica Mexicana*, Año I (for 1895) and II (for 1896), Mexico City, Secretaría de Fomento, 1899 and 1900. Cf. also Sapper, *Mittelamerikanische Reisen und Studien*, Braunschweig, 1902, p. 297. The Challenger data for Blewfields, Nicar., *l.c.*, p. 171, represent the prevailing wind as northwest, which has little bearing on the question of the relations of the continental and West Indian Odonata.

<sup>11</sup> On the other hand Chapman states that of the 550 species and subspecies of birds recorded from the West Indies, 303, or 55%, are endemic. *Bull. Amer. Mus. Nat. Hist.*, IV, p. 318, 1892.

TABLE 3.—THE RELATIVE STRENGTH OF THE WEST INDIAN AND SOUTH AMERICAN ELEMENTS IN DIFFERENT PARTS OF THE ODONATE FAUNA OF MEXICO AND CENTRAL AMERICA.

Area.	Total number of species, etc.	Number of species, etc., found also in the West Indies, and their percentage equivalents.	Number of species, etc., found also (outside of Mexico and Cent. Amer.) exclusively in S. Amer., and their percentage equivalents.
Mexican plateau .....	81	23 = 28.4%	14 = 17.3%
Mexico (as in Table 5)	219 (221)	49 (50) = 22.4 (22.6)	50 = 22.8 (22.6)
Yucatan and British Honduras.....	35?	18? = 51.4	8 = 22.8
Guatemala and Honduras.....	161 (186)	41 (50) = 25.5 (26.9)	49 (61) = 30.4 (32.8)
Costa Rica.....	101 (165)	19 (45) = 18.8 (27.3)	37 (65) = 36.6 (39.4)

(The parentheses have the same meaning as in Table 2, *q. v.*)

or almost entirely (*Argia*), confined to the Americas. *Lestes*, *Enallagma*, *Ischnura*, *Aeshna*, *Libellula* and *Sympetrum* are almost or quite cosmopolitan, but are more abundant in the northern than in the southern hemisphere.

Of the seven endemic genera, *Pseudostigma*, *Thaumatoneura* and *Paraphlebia* are South American in their affinities; the other four are not so clear.

Adding together the 9 species of these three genera, the 56 endemic species of genera also occurring in South America but not in Northern America (Table 4), and the 70 non-endemic species found elsewhere exclusively in South America (Table 1), we have a total of 135 species, or 46% of the fauna, as being of distinctly southern relationships. Similarly, adding the 12 endemic species of genera also occurring in Northern America, but not in South America (Table 4), to the 21 non-endemic species found elsewhere exclusively in Northern America (Table 1) we have a total of 33 species, or 11% of the fauna, as being of distinctly northern affiliations.

In the endemic as well as in the non-endemic species, therefore, the South American element<sup>12</sup> is much the strongest in Mexico and Central America as a whole.

<sup>12</sup> While the expression "South American element" has been used in these pages to designate those species found at the present time in South America also, there seems to be no evidence to decide whether such Odonata, or their ancestors, entered Mexico and Central America from the south, or whether South America received them from the former countries. Probably only further discoveries of fossil Odonata will settle this question.

TABLE 4.—DISTRIBUTION OF THE ENDMIC SPECIES, ETC., BY GENERA.

Subfamily and number of endemic species, etc.	Endemic.	Northern, but not South America.	Both Northern and South America.	West Indies.	South, but not North America.
Calopteryginae	11		Heterina.....	7 Heterina.	Cora..... 4
Lestinae	3		Leses.....	3 Leses.	
Agrioninae	80	Pseudostigma..... 2 Thaumatoaneura.... 2 Paraphlebia..... 5 Hesperagrion..... 1 Anisagrion..... 4	Argia..... 36 Enallagma..... 1 Argia. Ischnura..... 1 Enallagma. Ischnura. Telebasis..... 5 Leptobasis..... Metaleptobasis..... Neoneura..... 1 Protoneura..... 7	Mecistogaster..... 1 Phlogenia..... 3 Heteragrion..... 3 Hyponeura..... 1 Telebasis..... 5 Leptobasis..... 1 Metaleptobasis..... 4 Palænnema..... 4 Neoneura..... 2 Protoneura..... 7	Mecistogaster..... 1 Phlogenia..... 3 Heteragrion..... 3 Hyponeura..... 1 Telebasis..... 5 Leptobasis..... 1 Metaleptobasis..... 4 Palænnema..... 4 Neoneura..... 2 Protoneura..... 7
Gomphinae	25		Erpetogomphus.... 9 Progomphus.... 2	Gomphoides..... 2 Cyanogomphus..... 1 Epigomphus..... 5	Gomphoides..... 8 Cyanogomphus..... 1 Epigomphus..... 5
Cordulegastrinae	2		Cordulegaster..... 2		
Ephemerinae	3	Optonæshna..... 1	Eshna..... 2		
Corduliæ	1?		Macromia..... 1		
Libellulinae	16	Pseudoleon..... 1	Libellula..... 1 Erythrodiplax..... 2 Dythemis..... 1 Sympetrum..... 1	Micrathyria..... 1 Orthemis..... 2 Brechmorhogia..... 1 Tauriphila..... 1 Rhodopygia..... 1 Platylax..... 1	Micrathyria..... 1 Orthemis..... 1 Brechmorhogia..... 5 Tauriphila..... 1 Rhodopygia..... 1 Platylax..... 1
Totals, 141 spp.	7 gen., 16 spp.	3 gen., 12 spp.	11 gen., 57 spp.	15 gen.	20 gen., 56 spp.

Arranging the subfamilies in the order of their percentages of endemic species, the series obtained is Cordulegasterinæ (*two* species only) 100%, Gomphinæ 85.7%, Agrioninæ 72.2%, Calopteryginæ 47.8%, Lestinæ 42.8%, Libellulinæ 16%, Æshninæ 13%. The Cordulegasterinæ, many Gomphinæ, most Libellulinæ and Æshninæ have well-developed powers of flight. Perhaps the great majority of the other three subfamilies are feebly-flying insects, yet some of their species appearing in the present faunal district are very widely distributed, *e.g.*, *Enallagma civile*, *Ischnura ramburi*, *Anomalagrion hastatum*. It is consequently impossible to account for the relative endemicity of the subfamilies by such general considerations.

If the relative endemicity of these groups is not always inversely proportional to the powers of flight, as these figures seem to indicate, and if nearly 40% of the West Indian Odonata are not to be found in Mexico and Central America in spite of favoring winds, the explanation of the present distribution of this group of insects may perhaps be found in the past distribution of land and water<sup>13</sup> in these regions.

#### DISTRIBUTION OF THE ODONATA WITHIN LIMITED PORTIONS OF MEXICO AND CENTRAL AMERICA.

Table 2 and the remarks on the fauna of the Mexican plateau (page 463) have already illustrated this topic to some degree. Table 5 gives the number of endemic species and of those common to the three countries whose Odonate fauna is best known.

Accepting the areas of Mexico (exclusive of Campeche, Yucatan and Baja California), of Guatemala and of Costa Rica as approximately 655,000,<sup>14</sup> 63,000,<sup>15</sup> and 21,000 square miles (1,700,000, 164,000 and 54,000 square kilometres) respectively, it follows that, in proportion to its area, Costa Rica is much the richest country of the three, both in its total number of species and its number of endemic species.

Tables 6–8 give the number of species and the number of localities at which they were collected in each of the States or Departments of

<sup>13</sup> Compare the geological data embodied in the sketch maps of Gadow (*Proc. Zool. Soc. London*, 1905, II, pp. 235–6); also the discussions in the papers of Chapman (*Bull. Amer. Mus. Nat. Hist.*, IV, pp. 318, 326–9, 1892) on birds, Simpson (*Proc. U. S. Nat. Mus.*, XVII, pp. 428, 438, 447, 1894) on land and fresh-water mollusks, and Ortman (*Proc. Amer. Philos. Soc.*, XLI, pp. 309, 341, 347) on fresh-water decapods, of the West Indies.

<sup>14</sup> Romero, *Geographical and Statistical Notes on Mexico*, p. 91, New York, 1898.

<sup>15</sup> *Century Dictionary*, Vol. IX, New York, 1906. Dr. Sapper gives the approximate area of Guatemala as only 110,000 square kilometres, *Mittelamerikanische Reisen u. Studien*, p. 424.

TABLE 5.—DISTRIBUTION OF THE ODONATA BY SUBFAMILIES IN (a) MEXICO, EXCLUSIVE OF CAMPECHE, YUCATAN AND LOWER CALIFORNIA; (b) GUATEMALA AND EXTREME NORTHWESTERN HONDURAS, AND (c) COSTA RICA.

Subfamilies.	Totals in Mexico and Cent. Amer.				Restricted to				Common to				Totals in							
	Mex.		Guat.		C. R.		Mex. and Guat.		Mex. and C. R.		Guat.		Mex.		C. R.					
	gen.	spp.	gen.	spp.	gen.	spp.	gen.	spp.	gen.	spp.	gen.	spp.	gen.	spp.	gen.	spp.				
Calopteryginae.....	4	23	0	1	0	1	3	3	10	2(3)	4	2(3)	3	13	4?	14(16?)	2(3)	10(15)		
Lestinae.....	2	7	0	2	0	0	0	2	2(4)	2	2(3)	2	1(3)	2	6	2	2(4)	2	3(4)	
Agrioninae.....	24	112	1	27	0	12	0	9	18	43(44)	10(17)	21(30?)	10(18)	23(32)	19	74	20	61(62)	13(21)	38(49)
Gomphinae.....	5	28	0	13	0	0	0	3	4(5)	4(6)	3(5)	3(5)	2(4)	5	21	4(5)	77(9)	3(5)	6(9)	
Cordulegastrinae.....	1	2	0	1	0	0	0	0	1	1	1	1	1	1	2	1	1	1	1	
Aeshninae.....	6	23	0	2	0	0	0	0	4	11(17)	3	7(15)	3(4)	6(16)	5	19(20)	5	13(18)	3(4)	7(16)
Cordulinae.....	1	1	0	11	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	
Libellulinae.....	28	97	0	4	0	1	0	0	24	53(63)	17(23)	34(62)	17(25)	34(70)	26	83(84)	26	63(76)	17(25)	36(72)
Totals.....	71	293	1	51?	0	14	0	15	56(57)	124(144)	38(54)	72(119)	38(58)	72(131)	62	219(221)	62(63)	161(186)	41(61)	101(165)

"Spp." and the parentheses have the same meaning here as in Table 2.

TABLE 6.—NUMBER OF SPECIES, ETC., RECORDED FROM THE STATES, ETC., OF MEXICO, AND OF THE LOCALITIES AT WHICH THEY WERE COLLECTED.  
 (See explanation in the text.)

Pacific (Western) Slope.		Central Plateau.		Atlantic (Eastern) Slope.	
State.	Locality.	State.	Locality.	State.	Locality.
Sonora.....	4	7 Chihuahua.....	6	25 Coahuila.....	5
Sinaloa.....	3	26 Durango.....	4	15 Zacatecas.....	0
Tepic.....	7	52 Aguascalientes.....	1	9 S. Luis Potosi.....	4
Jalisco.....	8	62 Guanajuato.....	2	11 Queretaro.....	1
Colima.....	1	1 Michoacan.....	4	22 Hidalgo.....	1
.....	.....	1 Mexico.....	3	4 Tlaxcala.....	0
Guerrero.....	20	71 Distrito Federal.....	14	21 Puebla.....	4
Morelos.....	6	50	.....	9 Vera Cruz.....	9
Oaxaca.....	6	44	.....	Tabasco.....	23
Chiapas.....	2	13	.....	Campuche.....	1
Totals (after deducting duplications).....	57	120	Totals for Central Plateau States, after deducting duplications.	49	81
				Totals (after deducting duplications).....	45
					167

(Common to Atlantic and Pacific slopes of Mexico, 83 spp., subspp. et varr.)

Mexico, Guatemala and Costa Rica, respectively. In each table the States or Departments are arranged in vertical columns corresponding to their position on the Atlantic or Pacific slopes, and in the case of Mexico also on the Central Plateau. In each vertical column the names stand in order from north to south, and the States or Departments whose names are on the same horizontal line, in reading across these tables, are, in part at least, in the same latitude. These three tables exhibit the scantiness of our knowledge, however, rather than actual differences in the faunas.<sup>16</sup>

TABLE 7.—NUMBER OF SPECIES, ETC., OF ODONATA RECORDED FROM THE DEPARTMENTS OF GUATEMALA, AND OF THE LOCALITIES AT WHICH THEY WERE COLLECTED.  
(See explanation in the text.)

Pacific (Western) Slope.			Atlantic (Eastern) Slope.		
Department.	Locali-ties.	Speci-ties, etc.	Department.	Locali-ties.	Speci-ties, etc.
San Marcos.....	1	1	Alta Vera Paz.....	14	46
Quezaltenango.....	3	14	Izabal.....	9	64
Retalhuleu.....	3	22	Baja Vera Paz.....	6	51
Suchitepequez.....	1	16	Zacapa.....	2	40
Solola.....	1	2	Guatemala.....	3	16
Sacatepequez.....	1	9	Jalapa.....	1	13
Amatitlan.....	2	15			
Escuintla.....	7	47			
Santa Rosa.....	1	2			
Totals (after deducting duplications).....	20	68	Totals (after deducting duplications).....	35	139

Common to Atlantic and Pacific slopes 56 species, etc. Subtracting 56 from 68 + 139 gives 151 species from definite localities in Guatemala, or 10 less than the total (161) credited to that country in Tables 2 and 5. For these ten species definite localities are not known and hence they could not be included in Table 7. A similar difference exists between Tables 8, 5 and 2.

<sup>16</sup> The State of Vera Cruz, lying exclusively on the Atlantic slope, extending through  $5\frac{1}{2}$  degrees ( $17^{\circ} - 22^{\circ} +$ ) of latitude and 18,000 ft. (5,487 m.) of altitude, and having an area of 29,210 square miles (75,654 square kilometres), has 118 species of Odonata. The State of New Jersey, U. S. A., also bordering the Atlantic, reaching from  $39^{\circ}$  to  $41^{\circ} 15'$  N. and to 1800 ft. (550 m.) in elevation, and with an area of 7,815 square miles (20,241 square kilometres) possesses 111 species of Odonata. Both areas have been examined by a number of collectors of these insects, and the results do not seem to favor the general belief in the richness of tropical countries in Odonata. At least 9 species are common to the two areas: *Hetaerina americana*, *Argia translata*, *Ischnura ramburi*, *Anomalagrion hastatum*, *Anax junius*, *A. longipes*, *Libellula auripennis* (probably), *Pantala flavescens*, *Sympetrum corruptum*. As far as I am aware no data have been published showing a richer Odonate fauna in a limited period of time than that of the vicinity of Kent, Ohio, where Messrs. Osburn and Hine took 57 species between June 17 and 24 (*Ohio State University Naturalist*, I, pp. 13-15, 1900).

TABLE 8.—NUMBER OF SPECIES, ETC., OF ODONATA RECORDED FROM THE DEPARTMENTS OF COSTA RICA, AND OF THE LOCALITIES AT WHICH THEY WERE COLLECTED.  
(See the explanation in the text.)

Department.	Localities.		Species, etc.
	Pacific slope	Atlantic slope	
Guanacaste.....	1	.....	9
Alajuela.....	3	1	33
San José.....	8	3	46
Cartago.....	.....	6	46
Puntarenas.....	9	.....	29
Totals (after deducting duplications)	21	10	101

  

Total number of species, etc., Pacific slope.....	67
Total number of species, etc., Atlantic slope.....	59
Total number of species, etc., common to Pacific and Atlantic slopes.....	28

Although writers on other groups in the *Biologia* have distinguished between a "North" and a "South Mexico," the division line being near the Tropic of Cancer, the data at hand for the Odonata do not seem to indicate any such distinction.

#### RELATIONS OF THE ODONATE FAUNA TO TEMPERATURE.<sup>17</sup>

In Plate XXVI we have given a map of the distribution of mean annual temperatures in Mexico and Central America.<sup>18</sup> The topography, presenting a high paramesial axis running northwest and southeast through the greater part of the district, has brought about the existence of parallel zones of temperature, decreasing in mean annual intensity from each coast line to the axis. As a result the temperatures are not distributed latitudinally, but a high cool tract extends far

<sup>17</sup> It is not intended that the remarks here made on the relations of Odonate distribution to temperature, rainfall and other environmental factors are to be interpreted as showing the limits which these factors set to the distribution of the insects in question. Our knowledge of the areas occupied by the latter is still too imperfect to permit this. We may be said to know where many species occur, but not where they do not occur.

<sup>18</sup> Mr. C. H. T. Townsend, in his papers "On the Biogeography of Mexico, Texas," etc. (*Trans. Texas Acad. Sci.*, Vols. I and II, 1895 and 1897), has laid great emphasis on the difference between apparent and sensible temperatures, as obtained from dry and wet bulb thermometers respectively, holding that only sensible temperatures can be used in biogeographical work (*i.e.*, I, pp. 89-90; II, pp. 65-67). As very few wet bulb readings exist for our district, our data are those of his "apparent" temperatures only. I am indebted to Dr. C. C. Adams for calling my attention to these two papers, which seem to have been omitted from the "Zoological Record."

to the south of Mexico, thence continued as a chain of "islands" in the midst of lower and hotter lands. Considering the zones of mean annual temperature in order, from the hottest to the coldest:

Zone I (more than 30° C. = 86° F.) is doubtful, as stated in the explanation of the map; no species of Odonata are known to be restricted to the area supposed to constitute it.

Zone II (30°–25° C., 86°–77° F.) is continuous on the Atlantic, and also on the Pacific slope, for the entire length of its extent, from about 20° north latitude on the eastern, or 25° north on the western, coast of Mexico to South America. The Atlantic and Pacific belts of this zone are connected at the Nicaraguan lakes and at the Isthmus of Panama. This zone therefore offers a pathway for the extension, northward or southward, of species which find in it temperature conditions similar to those which prevail over large areas of South America.<sup>19</sup> It actually possesses a larger number (91) of species also found in South America than any other zone, although Zone III has 90 such species. Zones II and III have respectively 48 and 47 species also found in the West Indies, larger numbers than for the other zones. Peculiarities of Zone II are *Perilestes* (Costa Rica), *Argiallagma* (Guatemala), *Telebasis* 4 species, *Metaleptobasis*, *Neoneura*, *Protoneura* 5 species, *Nepheloptilia* and *Rhodopygia*, all genera found in South America and the West Indies. Yucatan, Campeche and most of British Honduras lie within this zone, and these three have no endemic species.

Zone III (25°–20° C., 77°–68° F.), the Mexican Tierra Caliente of Hann,<sup>20</sup> extends continuously southward from the Gulf States on the east, and from Arizona and California on the west, to southern Nicaragua, where it is interrupted by Zone II. The Atlantic and Pacific belts are confluent from the southern part of the State of Puebla to the western part of Chiapas, and again for the southern part of Honduras and most of Nicaragua. After its interruption in southern Nicaragua, this zone reappears in northwestern Costa Rica and extends almost to the Isthmus of Panama. Zones III and IV possess an equal number (27) of species also found in Northern America, a larger number than for the other zones. Characteristic for this zone are *Phlogenia* (not north of Costa Rica), *Palaemnema*, *Progomphus* 3 species, *Epigomphus* 4 species, genera chiefly South American in their distribution.

<sup>19</sup> The distribution of the Odonata by temperature zones in South America should also be considered here, but even the first steps in investigating the South American Odonata from this point of view have yet to be taken.

<sup>20</sup> *Handbuch der Klimatologie*, 2te Aufgabe, Bd. II, p. 285, Stuttgart, 1897.

Zone IV ( $20^{\circ}$ – $15^{\circ}$  C.,  $68^{\circ}$ – $59^{\circ}$  F.), the Mexican Tierra Templada of Hann, embracing a large part of the United States, nowhere touches the coasts in Mexico or Central America, as Zones II and III do, but occupies a central position. It consists in these countries of a Mexican portion, of rather greater area than that of the central plateau, and reaching to southern Puebla; a mostly elongated and narrow strip in Guerrero and Oaxaca, some of the western parts of Chiapas, Guatemala and Honduras, with an arm into western Salvador; a number of small scattered areas in Honduras and a larger one in northern Nicaragua; finally, an elongated strip in Costa Rica and Panama. Representatives of Zone IV are *Cordulegaster godmani*, *Aeshna dugesii*, *Plathemis subornata*, *Libellula comanche*, *foliata*, *nodisticta* and *luctuosa*, members of chiefly northern, or (*Aeshna*) cosmopolitan, genera.

Zone V ( $15^{\circ}$ – $10^{\circ}$  C.,  $59^{\circ}$ – $50^{\circ}$  F.), the Mexican Tierra Fria of Hann, occurs in scattered areas in Sonora, Chihuahua, Durango, Zacatecas, and one of greater extent in the States of Hidalgo, Puebla, Tlascala and Mexico; in western Guatemala and on some of the peaks of Costa Rica. No Odonata are peculiar to this zone.

Zone VI (less than  $10^{\circ}$  C. =  $50^{\circ}$  F.) occurs only on the higher peaks of Mexico, Guatemala and Costa Rica; no Odonata have been reported as yet at or above the elevations corresponding to its lower limit in these countries.

Zones III, IV, V and VI may be compared to continents or islands, lying within a sea of Zone II, and each enclosed by a girdle of zones of lower numbers than itself.

Table 9 gives the distribution of the Odonata within these zones.

From Table 9 it results that the number of species confined to one zone only is 104, extending through two zones 99, extending through three zones 71, and through four zones 8. Of all the zones, III contains the greatest number of species, subspecies and varieties, viz.: 222 as compared with 165 in II, 143 in IV, and 10 in V; it is also the richest in zonal endemic species, viz.: 46, as compared with 40 in II and 18 in IV; and the richest in endemic Mexican and Central American forms, viz.: 106, as compared with 60 in IV, 56 in II, 4 in V, and 3 in I.

The species, etc., which, outside of Mexico and Central America, are found exclusively in Northern America appear in the temperature zones of our district in the following numbers: IV 15, III 13, II 5, V 4. As our map (Plate XXVI) shows, zones IV and III are continuous from the United States into Mexico, so that they offer a pathway for the extension of species whose living conditions are

TABLE 9.—DISTRIBUTION OF THE ODONATA OF MEXICO AND CENTRAL AMERICA BY TEMPERATURE ZONES (cf. Map, Pl. XXVI).  
(The Arabic numerals are those of species, subspecies and varieties.)

Subfamilies.	Restricted to Zone					Common to Zones					Unknown, Totals.					
	I	II	III	IV	V	I-II	I-III	I-IV	I-V	II-III	II-IV	II-V	III-IV	III-V	IV-V	
Calopteryginae.....	3	3	3							5	3		5			23
Lestinae.....	1									3	1		1			7
Agriioninae.....	18	23	4	1	1	2	2			14	20	3	20	1		112
Gomphinae.....	4	10	1							1	3		7			28
Cordulegastrinae.....			1										1			2
Aeshninae.....	3	3	2							5	2		2			23
Cordulineae.....	3	1											2			4
Libellulinae.....	12	6	6							2						1
Total.....	40	46	18			1	2	4		50	64	4	47	5	1	293
Endemic.....	20	37	10			1	2			17	16		30	4		141
{ North'm Am.	1	3	5							3	11	3	6	1		37
{ South Amer....	18	6	4							4	28	40	1	11		115
{ West Ind....	5	2	2							15	26	2	2			56
Also found.....																
North'm Am.....										1	2		5	1	1	21
Northern	2												1			4
Am. and																
W. Ind.																
Northern																
Amer.																
N'th'n and																
S. Amer.																
and W. I.																
West Indies.....	2	1											3	4	1	12
West Ind. and																
So'h Amer.....	2	1	2							4		11	16	1		33
South Amer.....	15	4										16	17	10	2	70

Distribution elsewhere in America.

Exclusively in  
N'th'n and  
S. Amer.

those of these zones. The Northern American species found in zones II and V are, in all cases, also found in III or IV, and hence can conceivably have descended or ascended from one or the other of the latter two.

Considering all the Mexican and Central American species, etc., occurring also (a) in South America, or (b) exclusively in South America and the West Indies, or (c) exclusively in South America, the order (according to the number of species) of the temperature zones in which they appear is always the same, viz.: II, III, IV, I, V, the numbers of species being respectively: (a) 91, 90, 60, 4, 1; (b) 29, 29, 18, 0, 0; (c) 52, 51, 33, 4, 0. Zone II as a pathway for the extension of the "South American element" has already been considered on page 474.

*Some Anomalies in the Zonal Distribution.*—Since Zone II is the only zone continuously extending northward from South America, it is of importance to notice, as Table 9 shows, that of the 70 Mexican and Central American forms occurring elsewhere exclusively in South America, 16, or 23%, have not been detected in zone II in our faunal region.

Of the 131 species, etc., common to Mexico, Guatemala and Costa Rica, the great majority have been found in zone II at some point (and hence presumably occur in it at other points), although they may also inhabit other zones, but there are 28 exceptions.

Sixteen of the species, etc., of zones III and IV of Costa Rica are not found farther north, but 17 other species of the same zones and country do so extend, although the Costa Rican areas of these zones are discontinuous.

In spite of the isolation of zone IV in Guatemala, no species of Odonata are known to be restricted thereto, and species found there and not known to occur in any other zone than IV, such as *Cordulegaster godmani* and *Libellula foliata*, are also found in Mexico and in Costa Rica.

Sixty-two and 27 species, etc., of zones higher than II found in Mexico and Guatemala are not and are, respectively, found farther south, a discontinuity of zones III-V existing south of Guatemala.

Nine and 4 species, etc., of zones IV-V (but not lower) found in Mexico are not and are, respectively, found farther south.

Some conceivable explanations of these anomalies (suggested for future investigation) are: incompleteness of data on the present distribution; that temperature does not limit the inhabitable area of the species concerned, or that, limiting it, the species found in discontinuous parts of the same zone may at times, past or present,

have made their way from one separated area to another by their own powers of flight, perhaps aided by favorable winds; that zones III and IV may have been more continuous throughout the length of Mexico and Central America in Tertiary times, when higher elevations with consequent cooler temperatures prevailed over areas now low and hot, as a result of previous greater volcanic activity or orogenic revolution,<sup>21</sup> some of which latter causes have been invoked by botanists<sup>22</sup> to account for the distribution of the plants of this district.

That temperature is not the only factor in determining the distribution of the Odonata is shown by the fact that each of the zones II-IV, even when continuous over large areas, contains species of quite limited habitat within that zone. Such are *Perilestes fragilis*, *Argia wilsoni*, *gaumeri*, *popoluca*, and *cupraurea*, *Argiallagma minutum* and species of *Protoneura* in zone II; *Hetærina rufa*, *Argia percellulata*, *calida*, *barretti*, *rhaodsi* and *pocomana* and *Palæmnema desiderata* in zone III; *Hetærina tolteca* and *Argia herberti* in zone IV.

#### RELATIONS OF THE ODONATE FAUNA TO RAINFALL.

The existence of pools, lakes, or watercourses of sufficient constancy for the development of the aquatic larvæ of the Odonata is dependent on the water supply (ultimately traceable to the precipitation) and on the factors which tend to prevent its loss by evaporation or by sinking into the soil. These latter factors probably include frequency of winds and of clouds, sheltering vegetation and the relative porosity of the soil and underlying rocks. The supply and conservation of the water of a given area have not only the direct effects of furnishing the necessary living medium for the Odonate larvæ, but also, in a more indirect manner, must influence the supply of food for both larvæ and adults through the existence of vegetation and through it of herbivorous insects and other animals.

The influence of these environmental conditions on the Odonate fauna has not yet been thoroughly investigated even in those parts of the earth for which the physical data have been accumulated. For Mexico and Central America, where the collection of these data has been very limited (except at a few well-known localities), it is hardly possible at this time to attempt to correlate the facts of Odonate distribution even with those of precipitation. The existing measure-

<sup>21</sup> Hill, *Bull. Mus. Comp. Zool.*, XXXIV, pp. 205-207, etc., 1899.

<sup>22</sup> Most recently by Bray, *Science* for Nov. 9, 1900, pp. 709-716, and *Botan. Gazette*, XXVI, pp. 121-152, 1898, with citations from previous writers.

ments of rainfall show a much greater annual variation<sup>23</sup> than in the case of temperature, and a much longer series of observations is, therefore, needed to determine the approximate average rainfall than to ascertain the approximate mean annual temperature. Since such series exist for very few places<sup>24</sup> and the rainfall differs so much at nearby localities (as the data gathered by the authors quoted show), the endeavor to correlate the occurrence of certain species of Odonata with rainfall differences appears to be premature,<sup>25</sup> although it may be that precipitation has a more important influence on the distribution of these insects than has temperature.<sup>26</sup> The annual variation in rainfall, however, may bring about an annual variation in the local Odonate fauna—a possibility which suggests that a proper understanding of the insect fauna may be obtainable only from the same methods of accumulation of data as are practised by the meteorologists.

Mr. E. B. Williamson, as a result of his observations made while collecting in Guatemala, has suggested in correspondence that "The species [of Odonata] occurring at any location during the dry season are those species of widest distribution, or, in other words, local species are to be found in the height of the season." In testing this suggestion, the difficulty at once arises that we have no complete records of the Odonata occurring both in the wet and dry seasons at the same locality. An absolute essential for the study of this and other problems connected with the seasonal distribution of these insects in our district is a series of continuous observations for at least twelve consecutive months in the same limited area. Under the present conditions the best that can be done is to compare wet season captures at one point with dry season collections at the nearest similar station. Thus both Santa Lucia and Zapote lie on the Pacific slope of Guatemala,

<sup>23</sup> Escobar, *Memor. Soc. Cien. "Antonio Alzate,"* XX, 1903 (see his figures for Mazatlan, *e.g., l.c.*, p. 29). Harrington, *Bull. Philos. Soc. Washington*, XIII, pp. 6, 19, 1895. Sapper, *Meteorol. Zeitschr.*, 1892-1906. A still more recent review of the distribution of rainfall in Central America is contained in Dr. Alfred Merz's "Beiträge zur Klimatologie und Hydrographie Mittelamerikas" (*Mittheil. Vereins für Erdkunde zu Leipzig*, 1906; 96 pp., 4 Beilagen; 1907, especially pp. 9-23). An extended discussion of Dr. Merz's work is given in *Meteorol. Zeitschr.*, XXV, pp. 326 *et seq.*, July, 1908.

<sup>24</sup> These localities are mostly at the higher elevations, in the larger centres of human population, while the majority of the species of Odonata are found at lower levels.

<sup>25</sup> See a note by Mr. Champion (*Biol. Cent.-Amer. Neur.*, p. 53) and one by Mr. C. H. T. Townsend (*Ann. Mag. Nat. Hist.*, 6, XX, p. 289, 1897) on the seasonal appearance of certain Odonata and Diptera, respectively, in our district.

<sup>26</sup> Mr. F. M. Chapman has some interesting remarks on the influence of temperature, independent of humidity, on the distribution of birds at Las Vigas and Jalapa, Vera Cruz, Mexico (*Bull. Amer. Mus. Nat. Hist.*, X, pp. 17 and 36).

have a mean annual temperature of 25°–20° C. and a yearly rainfall of more than 3000 mm.,<sup>27</sup> the former, however, at an altitude of 335 metres as against 720 for Zapote. They have yielded respectively 26 dry season species and 17 wet season species; each has 6 endemic species (*i.e.*, restricted to Mexico and Central America), one of which, with 7 non-endemic species, is found at both localities.

The single locality in all Mexico and Central America which has furnished the greatest number of species of Odonata is Atoyac, in Vera Cruz—68. At least 59 of these were taken in April and May (the specimens of the other 9 are undated), and of these 59, 17 are endemic in Mexico and Central America. If we may judge from the rainfall figures published for the nearest point, Cordoba,<sup>28</sup> April and May, while not a part of the wet season in its stricter sense, may have a precipitation of 29–101 mm. and 77–233 mm. respectively, the total for the year being 2600–3200 mm. On investigating the seasonal records for the 17 endemic species at other localities, it appears that they are by no means always confined to one limited portion of the year.

Gualan, Guatemala, lies in the rainfall zone of less than 1000 m.<sup>29</sup> The only rainfall records from anywhere in the vicinity appear to be those of Teculutan, Department of Zacapa, the monthly figures for 1902, from January to December respectively, being 1, 0, 1, 95, 70, 361, ?, 38, 83, 164, 17 and 2 mm.<sup>30</sup> Mr. Williamson collected 39 species at Gualan in January, 1905, 7 of which are restricted to Mexico and Central America. At Los Amates, lying in the rainfall zone of 1000–2000 mm., in the same month and the following February, 35 species were obtained, 6 being endemic in our district. At Puerto Barrios, whose measured precipitation for three years, 1894–6, is 3096 mm., with no month below 50 mm.,<sup>31</sup> 33 species were procured in December, 1904, and February and March, 1905, 7 of these being confined to Mexico and Central America. Gualan has a well-marked dry season, which is much less distinct at Los Amates and absolutely, but not relatively, absent at Puerto Barrios. Of the endemic species, three taken at Gualan (*Argia tezpi*, *A. pipila*, *Pseudoleon superbus*), three at Los Amates (*Neoneura amelia*, *Protoneura remissa*, *Orthemis biolleyi*), and four at Puerto Barrios (*Hetaerina miniata*, *Argia gaumeri*, *Neoneura paya*, *Protoneura amatoria*) were not taken at either of the other

<sup>27</sup> Sapper, Petermann's *Mittheil.*, XLIII, map, 1897.

<sup>28</sup> For 1861–3, Nieto, *Bolet. Soc. Geog. Estadist. Mex.* (1), X, pp. 484 *et seq.*, 1864.

<sup>29</sup> Sapper, *l.c.*, 1897.

<sup>30</sup> Lottermoser, *Meteorol. Zeitschr.*, XXIII, pp. 237, etc., 1906.

<sup>31</sup> Sapper, Petermann's *Mittheil.*, XLIII, pp. 117 *et seq.*, 1897; *Meteorol. Zeitschr.*, XIV, p. 235, 1897.

two localities. Of the remaining endemic species taken at Gualan, two (*Argia frequentula*, *Telebasis digiticollis*) were taken also at both the other places, one (*Telebasis salva*) also at Los Amates, one (*Argia indicatrix*) also at Puerto Barrios.

Some other data are presented in Table 10 (see pp. 482, 483).

To illustrate the seasonal distribution more fully, the following lists of the species taken at three different localities are appended; the number before each specific name is the same as that employed in the list of species, Table B, of the Introduction, *Biol. Cent.-Amer. Neurop.*; names printed in heavy face type in this and other lists are those of species endemic in Mexico and Central America.

DISTRITO FEDERAL, MEXICO. No. 3. *Heterina vulnerata*, 25. *Lestes alacer*, 53. *Hyponeura funckii*, 101. *Argia agrioides nahuanus*, 108. *Enallagma civile*, 109. *E. prævarum*, 123. *Ischnura ramburi* and 124. var. *creedula*, 125. *I. denticollis*, 126. *I. demorsa*, 160. *Erpetogomphus crotalinus*, 171. *Cordulegaster diadema*, 175. *Anax junius*, 179. *Æshna multicolor*, 204. *Libellula nodisticta*, 221. *Orthemis ferruginea*, 267. *Tramea cophysa*, 280. *Sympetrum illotum virgulum*, 281. *S. corruptum*, 286. *Erythemis simplicicollis collocata*, 293. *Pachydiplax longipennis*.

April, 179; May, 25, 109, 125, 175, 179, 221, 280, 281, 286, 293; June, 53, 108, 109, 123, 124, 125, 126, 160, 179, 280, 281, 286, 293; July, 25, 101, 109, 123, 124, 125, 204, 267, 280, 281, 286, 293; August, 281, 286, 293; September, 3, 25, 101, 108, 109, 125, 126, 179, 280, 281, 293; October, 3, 25, 109, 124, 125, 171, 280; November, 280; December, 281.

CUERNAVACA, MORELOS, MEXICO. 3. *Heterina vulnerata*, 4. *H. americana*, 24. *Archilestes grandis*, 25. *Lestes alacer*, 43. *Paraphlebia hyalina*, 52. *Hyponeura lugens*, 53. *H. funckii*, 78. *Argia ænea*, 84. *A. lacrymans*, 85. *A. tonto*, 86. *A. fissa*, 88. *A. tarascana*, 92. *A. extranea*, 93. *A. vivida*, 94. *A. vivida plana*, 103. *Hesperagrion heterodoxum*, 107. *Anisagrion lais*, 119. *Telebasis salva*, 125. *Ischnura denticollis*, 127. *Anomalagrion hastatum*, 157. *Erpetogomphus elaps*, 159. *E. cophias*, 160. *E. crotalinus*, 162. *E. sipedon*, 171. *Cordulegaster diadema*, 178. *Æshna cornigera*, 179. *Æ. multicolor*, 181. *Æ. williamsoniana*, 183. *Æ. luteipennis*, 194. *Oplopanæschina armata*, 202. *Libellula saturata*, 203. *L. s. croceipennis*, 206. *Pseudoleon superbus*, 221. *Orthemis ferruginea*, 239. *Erythrodiplax connata* var. *b'* and 241. var. *d'*; 251. *Brechmorhogha tepeaca*, 253. *B. pertinax*, 261. *Paltothemis lineatipes*, 272. *Tramea onusta*, 275. *Perithemis domitia intensa*, 280. *Sympetrum illotum virgulum*, 281. *S. corruptum*.

January: Nos. 4, 24, 92, 93; May: 3, 4, 52, 78, 86, 92, 94, 107, 119, 202; June: 3, 24, 84, 92, 94, 103, 107, 159, 160, 178, 183, 202, 206, 221, 239, 261; July: 3, 24, 53, 92, 93, 127, 157, 159, 162, 181, 202, 203, 221, 253; August: 4, 24, 85, 88, 157; September: 3, 24, 103, 107, 119, 127, 160, 179, 275, 281; October: 3, 4, 24, 25, 84, 86, 88, 92, 93, 103, 107, 119, 127, 160, 171, 194, 202, 221, 239, 241, 251, 272, 280; November: 171.

SAN JOSÉ, COSTA RICA. No. 2. *Heterina cryentata*, 24. *Archilestes grandis*, 67. *Argia oculata*, 86. *A. fissa*, 92. *A. extranea*, 104. *Anisagrion allopterum* and 105. var. *rubicundum*, 113. *Acanthagrion gracile*, 157. *Erpetogomphus elaps*, 183. *Æshna luteipennis*, 203. *Libellula saturata croceipennis*, 221. *Orthemis ferruginea*, 237. *Erythrodiplax connata* var. *e*, 248. *Brechmorhogha vivax*, 254. *B. rapax*, 261. *Paltothemis lineatipes*, 273. *Pantala flavescens*, 280. *Sympetrum illotum virgulum*.

March: 203, 221, 248, 254, 273; May: 2, 67, 86, 92, 104, 105, 113, 157, 280; July: 24, 104; August: 24, 92, 183, 203, 221, 237, 261; September: 2; October: 2, 248.

From Table 10 and these three lists it is evident that the observations for different months in the same locality are quite unequal

TABLE 10.—NUMBER OF SPECIES, SUBSPECIES AND VARIETIES OF ODONATA TAKEN IN EACH MONTH AT SOME LOCALITIES IN WHICH THEY HAVE BEEN COLLECTED FOR MORE THAN THREE CONSECUTIVE MONTHS, WITH TEMPERATURES AND RAINFALLS ADDED FOR COMPARISON.

Period of Time.	Teapa, Tabasco, Mexico.		Tepic, Tepic, Mexico.		Cuernavaca, Morelos, Mexico.		Jalapa, Vera Cruz, Mexico.	
	Total number of species, etc.	Mean precipitation in mm., 1 year, 1884.	Total number of species, etc.	Mean precipitation in mm., 29 years, 1844-59.	Total number of species, etc.	Mean precipitation in mm., 2 years, 1886-68.	Total number of species, etc.	Mean precipitation in mm., 2 years, 1873-74.
January.....	35	10 (19.9)	822	10 (19.9)	4	18.5	.5	14.5
February.....	46	7 (23.1)	274	7 (23.1)	...	17.2	17.7	15.2
March.....	25	5 (24.8)	152	5 (24.8)	...	21.8	11.3	63.4
April.....	19	5 (26.0)	172	5 (26.0)	...	23.1	23.3	48
May.....	.....	26.4 (155)	.....	10 (155)	4	23.3	94.6	64.9
June.....	.....	26.9 (119)	.....	16	7	21.9	298.9	20.4
July.....	.....	25.9 (338)	7	1	14	5	20.7	228.7
August.....	.....	25.1 (773)	5	3	5	3	20.5	170.9
September.....	.....	25.2 (704)	.....	10	4	20.5	213.6	3
October.....	.....	23.8 (550)	27	10	23	10	20.6	56.2
November.....	.....	22.7 (569)	19	8	1	20.4	23.4	17.8
December.....	.....	22.8 (46)	2	1	2	18.1	18.2	9
Not dated.....	.....	.....	.....	.....	2	2	7	20.8.8
Year.....	65	17 (24.4)	42	16	43	21	20.5	1157.3
							24	6
							17.7	1461.9

Number of prede-

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

and Cent. Amer.

ing species, etc.,

restered to Mex.,

Period of Time.	Orizaba, Vera Cruz, Mexico.	San José, San José, Costa Rica.	Distrito Federal, Mexico.		
			Total number of species, etc.	Total number of species, etc.	Total number of species, etc.
January.....	14.2	°C. mm.	18.8	11.8	12.1
February.....	13.8	.....	19.3	1.5	13.7
March.....	17.6	.....	19.8	14.2	15.9
April.....	20.4	.....	20.4	40.6	17.7
May.....	22.9	9	20.5	230.	18.1
June.....	21.9	.....	20.1	291.	17.6
July.....	20.9	2	1	241.	12
August.....	20.8	7	19.7	257.	3
September.....	20.6	1	19.8	312.	11
October.....	18.9	204.	1	19.6	7
November.....	18.4	205.	1	19.4	1
December.....	14.6	19.5	1	154.	1
Not dated.....	8	6	18.8	39.	1
Year.....	29	11	(18.2)	.....	.....
			18	5	19.7
				1917.	21
					6
					15.4
					614.8

The climatic data quoted in this table have been obtained from the following sources. Those for Ixtacomitan, Chiapas, 210 m. alt., as the nearest point to Teapa, from *Meteorol. Zeitschr.* for 1895, p. 387; for Tepic from Escobar, *Mem. Soc. Cien.*, "Antonio Alzate," XX, pp. 40-1, 1903; for Cuernavaca from July 1, 1873, to June 30, 1874, from Reyes, *Bol. Soc. Geog. Estadist. Rep. Mex.*, (3) IV, pp. 90-128, 1878. For those for Jalapa, 1895-1907, and for Chimalhuacan, 1907, I am indebted to the Director of the Observatorio de Cuernavaca and to Señor G. M. Gonzalez, Director of the Observatorio Meteorológico de la Ciudad de Xalapa-Esquerra, both through the kindness of Señor Don Manuel E. Pastoriza, Director of the Observatorio Meteorológico-Magnético Central de Mexico. The data for Orizaba are from Moreno y Andrade and Gomez, *El Clima de la República Mexicana. Años I and II*, Mexico, 1899 and 1900. The data for San José, Costa Rica, are from Boletín Instit. Físico-Geog. Costa Rica, III, 1903; for the Federal District, Mexico, from the "Observatorio Meteorológico Central de Mexico," & summary of 12 pages and 2 tables issued by the Secretaría de Fomento, Mexico, 1892, and dedicated to the American Public Health Association.

and fall far short of giving a complete picture of the Odonate fauna. It is also clear, especially from the Cuernavaca list, where the same species appear at frequent intervals throughout the year, that a number of different, perhaps overlapping, broods must exist, as there is no reason for supposing that the life of an individual imago is prolonged for many months.

*Rainfall and Odonata on the Atlantic and Pacific Slopes.*—Various authors<sup>32</sup> have remarked the greater abundance of species of animals, including insects, on the Atlantic than on the Pacific slope of Mexico and much of Central America. Sumichrast (*I.c.*, p. 5) has attributed the relative poverty of the Pacific slope of Tehuantepec and adjoining areas in birds to “the extreme dryness of the soil; to the scarcity of vegetation and of insect life; and to the duration of the winds from the northeast and southwest which there prevail with great violence.” Harrington<sup>33</sup> has concluded that for Central America, “The rainfall is greater on the Atlantic than on the Pacific side as two or three to one.” Table 11 gives the distribution of the Odonata on these sides and on the Mexican plateau for the whole of our district, from which it appears that the total number of Atlantic slope species is 235 against 181 for the Pacific, a proportion of nearly 4 to 3. Tables 6–8 (pages 471–473) give the proportions for Mexico, Guatemala and Costa Rica respectively as, approximately, 4 to 3, 4 to 2, 4 to 4½.

Neither the rainfall nor the Odonate fauna can be summarized so briefly, however, as local conditions may cause both of these to vary. Not only the map of Puga,<sup>34</sup> but also the publications of Sapper<sup>35</sup> and of Lottermoser<sup>36</sup> show as heavy a rainfall on parts of the Pacific slope of Mexico and Guatemala as on the Atlantic side. The Odonate fauna of Altamira and Tampico, in Tamaulipas, numbers 40 species—that of Tepic 42; for Jalapa, Vera Cruz, we know 24 species, for Guadaluja 50; for the vicinity of the city of Vera Cruz, including Medellin,

<sup>32</sup> Sumichrast, quoted by Lawrence (*Bull. U. S. Nat. Mus.*, No. 4, 1876) for birds of the Isthmus of Tehuantepec. Godman (*Biol. Cent. Amer. Lepid. Rhopal.*, I, p. vi, 1901) for Lepidoptera Rhopalocera generally “to perhaps as far south as Costa Rica.” V. Martens (*Biol. Cent. Amer. Land and Freshw. Moll.*, p. xxvii) for this group to the same distance; he correlates the greater abundance of species with the greater area of the Atlantic slope of Mexico, Guatemala, Honduras and Nicaragua. Champion (*Entom. News*, XVIII, p. 33, 1907) for insects of Guatemala.

<sup>33</sup> *Bull. Philos. Soc.*, Washington, XIII, p. 7, 1895.

<sup>34</sup> “Distribucion de las Lluvias en la Republica Mexicana,” *Mem. Soc. Cien., Antonio Alzate*, XVI, 1901.

<sup>35</sup> Petermann’s *Mittb.*, XLIII, pp. 117 *et seq.* and map, 1897; *Das Nördliche Mittelamerika*, pp. 182–3; *Mittelamerikanische Reisen u. Studien*, pp. 299–300.

<sup>36</sup> *Meteorol. Zeitschr.*, XXIII, pp. 237 *et seq.*, 1906.

TABLE 11.—DISTRIBUTION OF THE SPECIES, ETC., OF ODONATA OF MEXICO AND CENTRAL AMERICA BY SLOPES AND (IN MEXICO)  
THE CENTRAL PLATEAU.  
(A = Atlantic, P = Pacific, slope,<sup>37</sup> C = Central Mexican plateau.)

Subfamily.	Exact distribution unknown	Restricted to			Common to				Totals
		A	C	P	A C	A P	C P	A C P	
Calopteryginae.....	1	13	0	3	0	3	0	3	23
Lestinae.....	3	0	1	0	1	0	2		7
Agrioninae.....	4	39	0	14	2	32	5	16	112
Gomphinae.....	2?	9	1	7	1	2	3	3	28?
Cordulegastrinae.....						1		1	2
Æshninae.....	4	5	1	1	0	6	1	5	23
Cordulinæ.....	1								1
Libellulinae.....		17	2	4	7	39	4	24	97
	11	87	4	30	10	84	13	54	293
Endemic species, etc.....	4	59	1	22	2	30	10	13	141
Occur also in Northern Amer.....	3	2	3	1	6	6	2	14	37
Occur also in S. Amer....	3	22	0	8	3	48	1	30	115
Occur also in W. Indies.	2	11	0	1	3	19	1	19	56

11 species are now recorded, for Acapulco 19. In Pacific Guatemala the highest number recorded for one locality is 26 at Santa Lucia, which is exceeded at various stations on the Atlantic slope, but this latter has received much more attention from the collectors whose material is accessible.

Generally we may conclude that the hot moist areas of Mexico and Central America are tenanted by the greatest number of forms of Odonata, present information pointing to the richest areas as lying in temperature zone III and the higher parts of zone II, on the Atlantic slope, from the centre of the State of Vera Cruz southward, these areas having a heavy annual rainfall.

In this connection may be mentioned the suggestion of a possible

<sup>37</sup> The terms "Atlantic" and "Pacific slopes" are here used in the wide sense as embracing: (a) in Mexico all the descending lands from the outlines of the plateau, as shown on our map (Plate XXVI), to the Gulf of Mexico on the one side and to the Pacific Ocean and Gulf of California on the other; (b) in Mexico south of the plateau and in Central America, as corresponding to the Atlantic and Pacific drainage areas respectively.

correlation between paleness of wing-veins and dryness of climate,<sup>38</sup> which seems to receive some support from *Argia mæsta*<sup>39</sup> and *Enallagma civile*,<sup>40</sup> but, on the other hand, appears to be negatived by specimens of *Enallagma prævarum* from many of the same localities which furnish *E. civile*.<sup>41</sup>

Whatever of a more exact character we learn in the future of the dependence of these insects on climatic conditions, we must conceive of the latter as operating in a manner which may be compared to the beating of the waves upon a shore. A higher temperature and a more copious rainfall, together or singly, advance upward to a greater elevation or northward to a higher latitude, making possible the existence of certain species in the larval state where they were previously unknown. The next year, or after several years, these favorable conditions retreat down the mountain slopes or southward along the coastal plains, and the species whose existence they permitted disappear from certain localities for a longer or shorter period of time until the necessary conditions are again established.<sup>42</sup> To demonstrate the correctness of this view such continuous observations at a number of stations as were mentioned above (page 479) are essential.

#### RELATIONS OF THE ODONATE FAUNA TO VEGETATION AREAS.

Dr. Charles C. Adams, whose recent researches have been directed chiefly to the detection of the relations of faunæ to their physiographic surroundings, has suggested to me to endeavor to correlate the distribution of these insects with that of vegetation areas, the latter to serve as indices of the general physical features of the country. In this attempt I have employed Dr. Karl Sapper's vegetation maps of Central America,<sup>43</sup> locating the various places at which the Odonata have been collected in his zones and tabulating the distribution of the species accordingly. The results, save in a few instances to be mentioned shortly, have been unsatisfactory, as the great majority of species appear in several columns of the tabulation. Thus of 133

<sup>38</sup> *Biol. Cent.-Amer. Neurop.*, p. 235.

<sup>39</sup> *L.c.*, p. 361.

<sup>40</sup> *L.c.*, pp. 110, 380.

<sup>41</sup> *L.c.*, p. 380.

<sup>42</sup> Some remarks by Mr. S. E. Meek (*Publicat. Field Columb. Mus. Chicago*, V, pp. xxvi-xxvii, 1904), on the effects on the fish fauna of fluctuations in bodies of water on the northern part of the Mexican plateau, may also be applied to Odonate larvæ.

<sup>43</sup> In *Das Nördliche Mittelamerika* (map dated 1895), 1897, and *Mittelamerikanische Reisen und Studien* (map dated 1900), 1902. There is also a larger scale map for Guatemala only, dated 1894, in Petermann's *Mittheil.*, Ergänzungsband XXIV.

species so tabulated, six (*Heterina cruentata*, *Argia fissa*, *A. extranea*, *Acanthagrion gracile*, *Ischnura ramburi* var. *creedula*, *Perithemis dominia iris*) occur in all of the four zones in which these insects have been collected, viz. (names as given in Sapper's, 1895, map for Guatemala): 1. Savannas and stretches of primeval forest alternating (wet), 2. Tropical and subtropical rainy forests, 3. Oak and pine forests of the hot and temperate climates, 4. Grass- and bush-steppes and dry forests. Twenty-four species (*Heterina tricolor*, *H. macropus*, *Argia pulla*, **A. indicatrix**, *A. aenea*, *Enallagma cæcum novæ-hispaniæ*, **Telebasis salva**, *Leptobasis vacillans*, *Uracis imbuta*, *Orthemis ferruginea*, *O. levis*, **Erythrodiplax funerea**, *E. umbrata*, *E. ochracea*, *E. connata* var. *d*, *Dythemis velox*, *D. cannaciroides*, *Brechmorhoga præcox*, *B. inequius*, *Macrothemis pseudimitans*, *Paltothemis lineatipes*, **Sympetrum illotum virgulum**, *Erythemis verbenata*, *Lepthemis vesiculosa*) appear in three zones. More than thirty species (including such endemic forms as **Cora marina**, **Heteragrion tricellulare**, **Argia frequentula**, **Telebasis digiticollis**, **Neoneura amelia**, **Erpetogomphus viperinus**, **Brechmorhoga pertinax**) are common to zones 2 and 4, but not to others.

This does not necessarily mean that a correlation of Odonate species with vegetation formations does not exist. It may be that slight local differences of too small an area to be shown on the maps employed, or that our data based solely on the imagos, not on the larvæ, are responsible for its apparent absence.<sup>44</sup>

The few instances, above referred to, in which some correlation seems to exist are those of certain Odonata occurring in the tropical and subtropical rainy forest areas, as the species of *Protoneura*, *Paraphlebia*, *Argia*, *Allagma*, *Ephidatia* and *Nepheloptilia*, and, less certainly, of other genera of the legions *Podagrion* and *Protoneura*. From the notes of collectors which have been quoted under the respective species<sup>45</sup> it would also appear that members of the legion *Pseudostigma* are dwellers in forests,<sup>46</sup> although not necessarily wet forests.

<sup>44</sup> Those disposed to make further researches as to the existence of such correlations will doubtless find assistance in Señor Jose Ramirez' "La Vegetacion de Mexico" (*Anales, Ministerio de Fomento, Repub. Mex.*, XI, pp. 227-489, 1898). His botanico-geographical regions, however, are not shown on any of the maps accompanying his memoir.

<sup>45</sup> *Biol. Cent.-Amer. Neurop.*, pp. 53, 56, 353. Cf. also Selys, *Mem. Couron. Acad. Sci. Belg.*, XXXVIII, p. 9, footnote, 1886.

<sup>46</sup> With the clearing of these forests, now apparently in progress (cf. Belt, *Naturalist in Nicaragua*, pp. 185-6; Sapper, *Mittelamerikanische Reis. u. Stud.*, pp. 308-9), we must probably expect the disappearance of these Odonata.

## RELATIONS OF THE ODONATE FAUNA TO ALTITUDE.

Table 9, page 476, in connection with the map (Plate XXVI), may be used as indicating not only temperature zones, but also the elevated or non-elevated character of the country in which Odonata have been found, the higher zone numbers corresponding to higher altitudes. Zone II in Central America and in Mexico south of 20° N. Lat. (25° N. Lat. on the Pacific side) embraces all the low coast lands. The highest point on the Atlantic slope of Mexico to which it attains appears to be Actopan,<sup>47</sup> in Vera Cruz (311 m.<sup>48</sup>), whence it descends to sea-level south of Tuxpan, while on the Pacific slope it reaches 487 m. at the city of Colima<sup>49</sup> and sea-level north of Culiacan. Its upper limit in Central America is about 270 m.

North of zone II the coasts of Mexico fall in zone III, which, with the higher parts of zone II, includes everywhere the gradually ascending slopes of the central plateaus and mountain ranges to an elevation of about 1,160 m. in Central America, 1,560 m. at Oaxaca City, 1,000 m. at Mirador, Vera Cruz, 700 m. in Nuevo Leon and higher than this last in Sonora.

In zones IV and V the larger rivers arise, to descend (except in some parts of northern Mexico) through zones III and II to the sea. Zone IV extends to an elevation of 2,050 m. in Central America, 2,200 m. in the southern part of the Mexican plateau, but to not above 1,200–1,300 m. in places in New Mexico.

The only species which appear to be exclusively confined to the actual sea-coast are *Aeshna brevifrons*, *Erythrodiplax berenice næva* and *Tramea longicauda* var. *Libellula auripennis* is chiefly a sea-coast species, but in Mexico, as in the United States, has been found elsewhere. A larger number (16)<sup>50</sup> of forms are not known to descend below the lower limits of zone IV and are, in our district, markedly highland species. Such are **Hetærina tolteca**, **H. maxima**, **Cora skinneri**, *Lestes henshawi*, **Argia terira**, **herberti**, **chelata** and **tonto**, *Progomphus obscurus borealis*, **Cordulegaster godmani**, *Aeshna dugesii*, *Plathemis subornata*, *Libellula comanche*, **foliata**, *nodisticta* and *luctuosa*. The remaining 274 forms have an intermediate or a more varied habitat,

<sup>47</sup> Moreno y Anda and Gomez, *El Clima de la Republ. Mex.*, Ano II, p. 136.

<sup>48</sup> *Revista Soc. Cien.*, "Antonio Alzate," XXIII, pp. 31, 32, 1905.

<sup>49</sup> Hann, *Hdb. d. Klimatologie*, IIte Aufgabe, II, p. 286.

<sup>50</sup> The apparent discrepancy between this figure (16) and that to be obtained (19) from Table 9, page 476, is due to the fact that the three other species or varieties, *Anax longipes* and *Erythrodiplax connata a'* and *c'*, while as yet found only in zone IV in Mexico and Central America, have been taken at lower levels in South America or in the West Indies.

in some cases restricted apparently to a single locality (**Hetærina rufa**), in others having a wide range of elevation, as from the sea-coast to the central plateau (*Anomalagrion hastatum*, *Ceratura capreola*). Where the same species of *Ischnura* has been found at quite different altitudes, a slight increase in body size and in the number of post-cubitalia has been detected in specimens from the higher stations.<sup>51</sup>

In concluding this discussion of the relations of the Odonata to various factors of their environment, lists of the forms recorded from a few localities of decidedly different physical character are appended. See also the lists given for the Distrito Federal, Cuernavaca and San José on page 481.

GUZMAN, Chihuahua (desert of Northern Mexican plateau, mean annual temperature probably near 18° C. or 64 F.; altitude 1,341 metres or 4,400 feet), all the following species were seen or taken Aug. 6 and 7, 1906: *Argia moesta*, *Enallagma civile*, *Ischnura ramburi* var. *credula*, *Anax (junius?)*, *Plathemis subornata*, *Orthemis ferruginea*, *Tramea* sp., *Pantala flavescens*, *Sympetrum corruptum*, *Erythemis simplicicollis* or its subspecies *collocata*.

MAZATLAN (Pacific sea-coast, mean annual temp. 1880-1902, 24.9° C. or 76.8° F.; mean ann. rainfall 1880-1901, 806 mm. or 32.25 inches): *Mecistogaster ornatus*, *Argia pulla*, *Enallagma cœcum nova-hispaniae*, *Leptobasis vacillans*, *Ischnura ramburi* and var. *credula*, *Pseudoleon superbus*, *Orthemis ferruginea*, *Erythrodiplax funerea*, *Brechmorhoga postlobata*, *Macrothemis inacuta*, *Miathyria marcella*, *Tramea longicauda* var. *T. onusta*, *Pantala flavescens*, *P. hymenaea*, *Perithemis domitia intensa*, *Cannacria batesii*, *Erythemis verbenata*, *Leptemis vesiculosa*.

ATOYAC, Vera Cruz (moist Atlantic slope of Mexico, cf. page 480, *antea*; mean ann. temp. probably about 22.7° C. or 72.9° F.; alt. 400 m. or 1,314 ft.): *Hetærina cruentata*, *H. titia*, *H. macropus*, *H. infecta*, *Cora marina*, *Archilestes grandis*, *Lestes tenuatus*, *Megaloprepus cœrulatus*, *Pseudostigma aberrans*, *Mecistogaster ornatus* and *modestus*, *Heteragrion chrysops*, *Hyponeura funckii*, *Argia percellulata*, *translata*, *frequentalia*, *ulmeca*, *oculata*, *cuprea*, *enea*, *fissa* and *extranea*, *Anisagrion lais*, *Enallagma cœcum nove-hispaniae*, *Acanthagrion gracile*, *Leptobasis vacillans*, *Palæmnema paulina* and *angelina*, *Protoneura aurantiaca*, *Gomphoides suasa*, *Erpetogomphus viperinus* and *ophibolus*, *Cyanogomphus (?) tumens*, *Aeshna cornigera*, *virens* and *perrensi*, *Gynacantha trifida* and *tibiata*, *Libellula herculea*, *Pseudoleon superbus*, *Tholymis citrina*, *Micrathyria didyma*, *dissocians* and *ocellata*, *Orthemis ferruginea* and *levis*, *Cannaphila vibex*, *Anatya guttata*, *Erythrodiplax funerea*, *umbrata*, *ochracea*, *connata* vars. *d* and *e*, *Dythemis velox*, *Brechmorhoga vivax*, *praecox*, *pertinax*, and *inequiunguis*, *Macrothemis pseudimitans* and *hemichlora*, *Miathyria simplex*, *Tauriphila azteca*, *Perithemis domitia iris* and *d. moma*, *Erythemis peruviana*, *attala* and *verbenata*, *Leptemis vesiculosa*.

PUEBRO BARRIOS (Atlantic coast of Guatemala, see page 480; mean ann. temp. for 1896, 26.8° C. or 80.3° F.): *Hetærina tricolor*, *titia* and *miniata*, *Heteragrion chrysops*, *Argia translata*, *gaumeri*, *frequentalia* and *indicatrix*, *Acanthagrion gracile*, *Telebasis digiticollis*, *Anomalagrion hastatum*, *Ceratura capreola*, *Neoneura paya*, *Protoneura amatoria*, *Epidatia longipes cubensis*, *Uracis imbuta*, *Micrathyria debilis* and *eximia*, *Nephepeltia phryne*, *Anatya normalis*, *Erythrodiplax umbrata*, *ochracea*, *connata* vars. *c*, *d*, *e*, *Dythemis velox*, *Macrothemis hemichlora*, *Tauriphila argo*, *Tramea insularis*, *Pantala flavescens*, *Perithemis domitia iris*, *Erythemis verbenata*, *Leptemis vesiculosa*.

SAN GERONIMO (dry, elevated central Guatemala; mean ann. temp. probably 20°-21° C. or 68°-69.8° F.; mean ann. rainfall less than 1,000 mm. or 40 inches; alt. 900 m. or 2,950 ft.): *Hetærina cruentata*, *capitalis* and *rufa*, *Amphiptynx*

<sup>51</sup> *Biol. Centr.-Amer. Neurop.*, pp. 387-389.

*agrioides*, *Cora marina*, *Archilestes grandis*, *Heteragrion tricellulare*, *Hyponeura funckii*, *Argia fissa*, *Acanthagrion gracile*, *Telebasis salva*, *Anomalagrion hastatum*, *Progomphus pygmaeus*, *Epetogomphus viperinus* and *elaps*, *Anax amazili*, *Æshna multicolor* and *luteipennis*, *Gynacantha septima*, *Orthemis ferruginea*, *Cannaphila vibex*, *Erythrodiplax funerea*, *umbrata* and *connata* var. *d*, *Dythemis velox* and *maya*, *Brechmorhoga pertinax*, *rapax* and *inequiunguis*, *Macrothemis pseudimitans*, *Paltothemis lineatipes*, *Tramea abdominalis*, *Pantala flavescens*, *Lepthemis vesiculosa*.

CACHI, Costa Rica (moist Atlantic slope; mean ann. temp. probably about 20.6° C. or 69° F.; mean ann. rainfall 1902-04, 2,200 mm. or 86.78 inches; alt. 1,020 m. or 3,345 ft.): *Heterina cruentata*, *macropus*, *capitalis* and *majuscula*, *Archilestes grandis*, *Megaloprepus carulatus*, *Mecistogaster modestus*, *Heteragrion chrysops* and *erythrogasterum*, *Argia frequentula*, *rogersi*, *fissa*, *variabilis*, and *extranea*, *Anisagrion allopterum* and var. *rubicundum*, *Enallagma cæcum novæ-hispaniae*, *Epigomphus tumefactus* and *subobtusus*, *Anax amazili*, *Æshna luteipennis*, *Gynacantha trifida*, *Libellula herculea*, *Orthemis ferruginea*, *Cannaphila vibex*, *Erythrodiplax funerea* and *connata* var. *d*, *Brechmorhoga vivax*, *pertinax* and *rapax*, *Paltothemis lineatipes*, *Pantala flavescens*.

SURUBRES, Costa Rica (Pacific slope, drier; mean ann. temp. probably about 25° C. or 77° F.; alt. about 250 m. or 820 ft.): *Hetærina fuscoguttata*, *cruentata* and *macropus*, *Mecistogaster ornatus*, *Heteragrion erythrogasterum*, *Perilestes fragilis*, *Argia translata*, *tezpi*, *pulla*, *frequentula*, *adamsi*, *difficilis*, *cupraurea* and *œnea*, *Acanthagrion gracile*, *Ceratura capreola*, *Uracis imbuta* and *fastigiata*, *Orthemis ferruginea*, *Erythrodiplax funerea* and *connata* vars. *c* and *e*, *Dythemis velox*, *Brechmorhoga vivax*, *Macrothemis hemichlora*.

#### EXPLANATION OF PLATE XXVI.

Map showing the distribution of actual mean temperatures in Mexico and Central America.

This map was especially prepared by the writer for the *Biología Centrali-Americana*, volume *Neuroptera*. Acknowledgment is due to Dr. F. D. Godman, editor of that work, for permission to reproduce it here. It is based on data from the following sources:

For the United States: Prof. A. J. Henry's "The Climatology of the United States" (*Bulletin Q. U. S. Weather Bureau*, Washington, D. C., 1906, 4to).

For Mexico: 1. A map, 97 x 71.5 cm., in the library of the Academy of Natural Sciences of Philadelphia, inscribed merely "Carta Climatologica. Sebastian Reyes. P. I. Senties. A. Donamette Imp. Escala de 1: 3,000,000. Gravée chez Monrocq fr. Paris." Thanks to the Secretaría de Estado y del Despacho de Fomento Colonizaciòn e Industria de Mexico, I am informed, under date of July 30, 1907, "que dicha Carta fué publicada en 1889 por disposicion de esta Secretaría, haciendo los trabajos relativos los Sres. Pedro J. Senties, que era Director de la Escuela Nacional de Agricultura y Comisionado de México en la Exposicion de Paris del mismo año y Sebastian Reyes que fué Profesor del Plantel antes mencionado." This map was reproduced without alteration, but on a reduced scale (1 : 6,000,000), in Tome XI, *Anales del Ministerio de Fomento de la República Mexicana*, Mexico, 1898.

2. A map entitled "Reparticion de la Temperatura en la República Mexicana" for the "Año Meteorológico de 1902," published as Plancha 16, *Boletín Mensuel, Observatorio Meteorológico-Magnético Central de México*, Noviembre, 1902. Señor Don Manuel E. Pastrana, Director of the Observatorio, has kindly informed me (Sept. 6, 1907) that the maps for later years have not been published.

3. A number of temperature data for 70 stations in the State of Vera Cruz and 49 in other parts of Mexico, gathered from all accessible sources and published by the writer in the *Monthly Weather Review*, Vol. XXXVI, No. 4, pages 93-97, Washington, D. C., April, 1908. Issued June 16, 1908.

4. The topography of the country as given in the map issued by the Bureau of American Republics, Washington, D.C., 1900. The limits of the central plateau are taken from the map published in the *Boletín Mensuel, Observat. Meteor.-Mag. Cent. Mex.* for July, 1901.

It should be added that the existence of zone I, with a mean annual temperature of more than 30° C., rests solely on the authority of the map of Sentries and Reyes, that it is doubted by Señor Pastrana, and that I have not succeeded in finding any records of temperature observations in the valley of the Rio de las Balsas for a period of more than two months.

For *Central America*, the temperature records quoted in the paper in the *Monthly Weather Review*, above mentioned, indicate that in Guatemala and Costa Rica the annual isotherms of 25°, 20°, 15°, 10° and 5° C. are situated approximately at elevations of 270, 1,160, 2,050, 2,950 and 3,840 metres respectively. The present map, so far as Central America is concerned, has been made from the topographical maps of Dr. Sapper (Petermann's *Mittheilungen*, L, 1904, and *Ergänzungsbänder* XXVII and XXXII, 1899 and 1905; and *Mittelamerikanische Reisen und Studien*, Braunschweig, 1902) and of the Bureau of American Republics for Guatemala (1902), Nicaragua (1903) and Costa Rica (1903), by using these equivalents.



### ACTUAL DISTRIBUTION OF MEAN ANNUAL TEMPERATURES

- Zone I More than  $30^{\circ}\text{C}.$  ( $86^{\circ}\text{F}.$ )?
- " II  $30^{\circ}-25^{\circ}\text{C}.$  ( $86^{\circ}-77^{\circ}\text{F}.$ )
- " III  $25^{\circ}-20^{\circ}\text{C}.$  ( $77^{\circ}-68^{\circ}\text{F}.$ )
- " IV  $20^{\circ}-15^{\circ}\text{C}.$  ( $68^{\circ}-59^{\circ}\text{F}.$ )
- " V  $15^{\circ}-10^{\circ}\text{C}.$  ( $59^{\circ}-50^{\circ}\text{F}.$ )
- " VI Less than  $10^{\circ}\text{C}.$  ( $50^{\circ}\text{F}.$ )

- - - International Boundaries  
 - - - Boundaries of Mexican States  
 - - - Limits of Central Mexican Plateau

110

105

100

95

